

Recent results on wave-particle interactions as inferred from SCATHA

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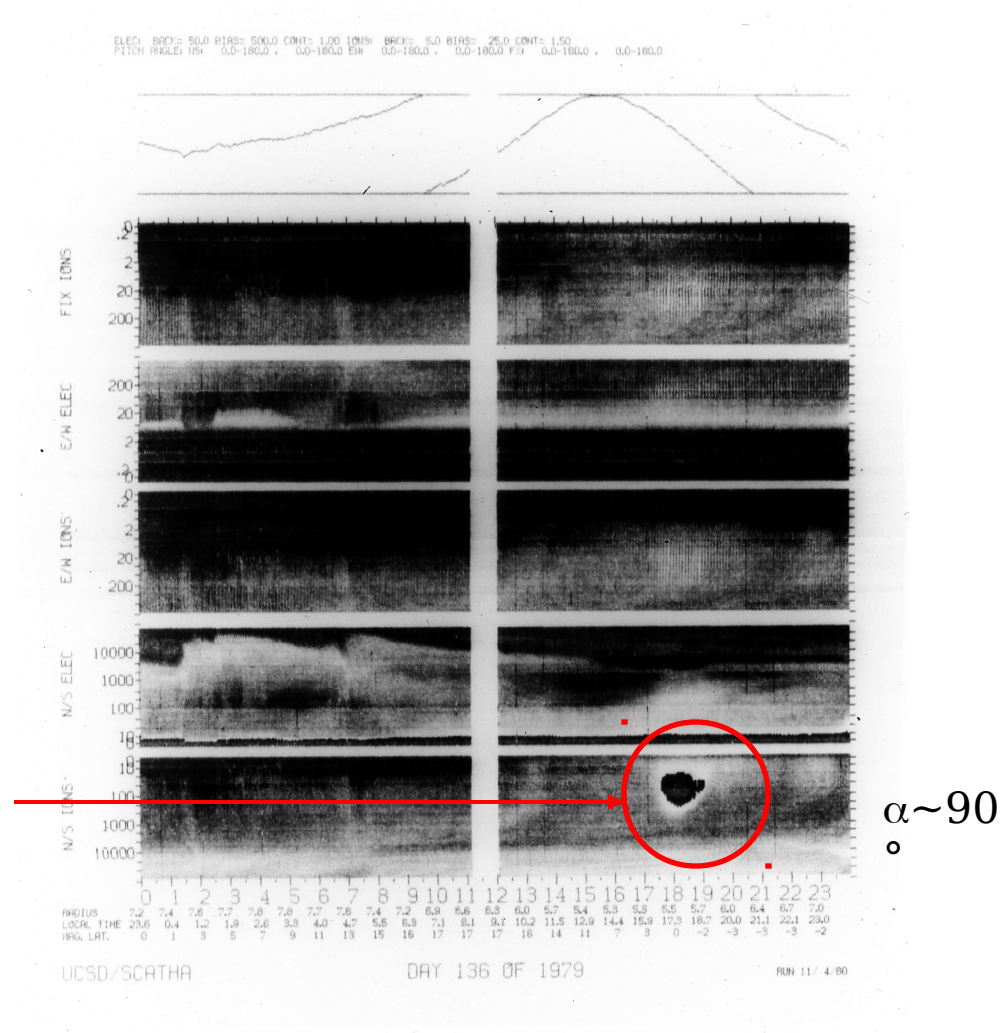
Plasma Observations

Plasma data from the SCATHA satellite.

There are 5 detectors - 3 for ions, 2 for electrons. The "NS" detectors are the high energy pair - 0-81 KeV. The "LO" and "FIX" detectors cover 1-1800 eV. The LO and FIX detectors are viewing at variable pitch angle (α), the NS detector is viewing parallel to the spin axis, at $\sim 90^\circ$

The trace at the top is the magnetic field strength.

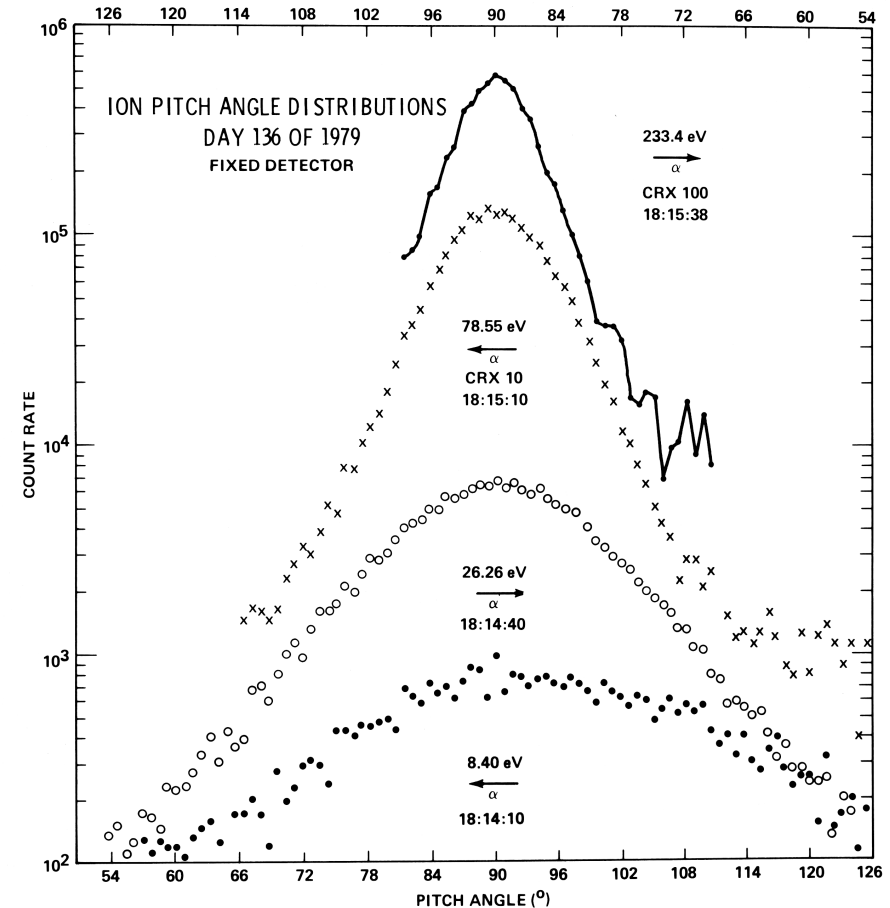
The large black spot is the equatorially trapped plasmas - the grey scale overflowed for the display; this is not instrument saturation.



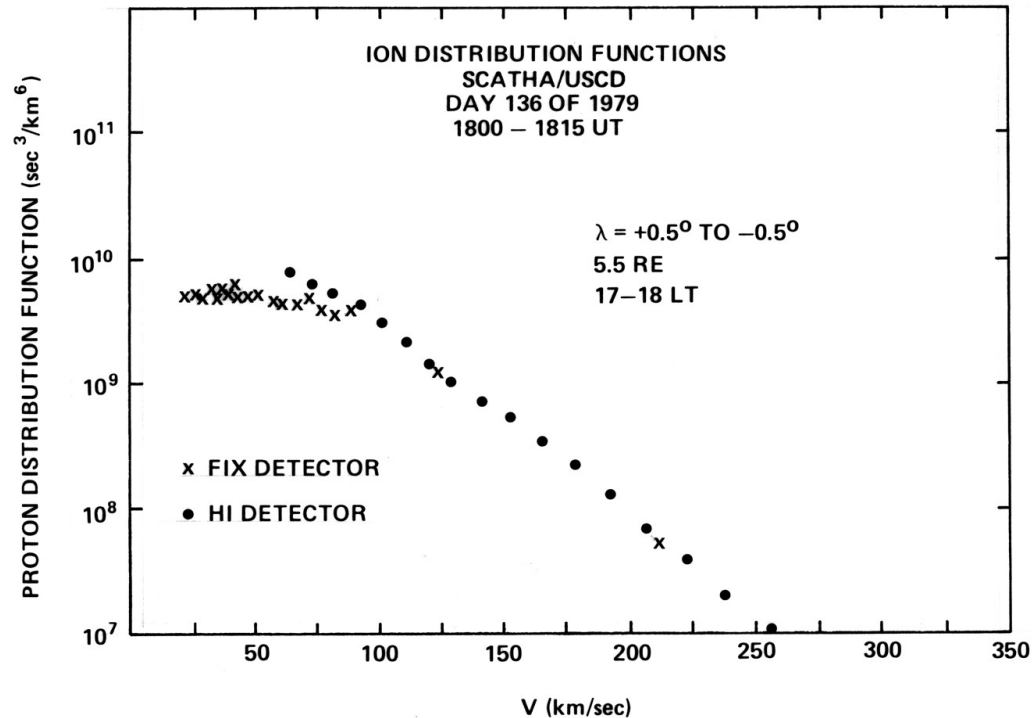
$\alpha \sim 90^\circ$

Pitch Angle Distributions - Day 136

- The ion pitch angle distributions are very narrow.



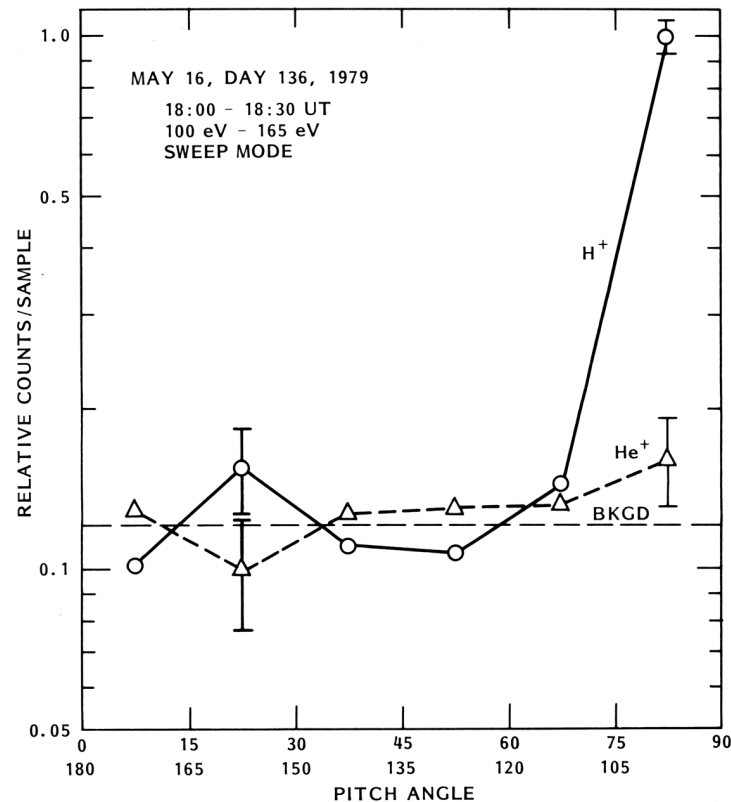
Velocity Distribution Function



- The distribution functions are not really Maxwellian.

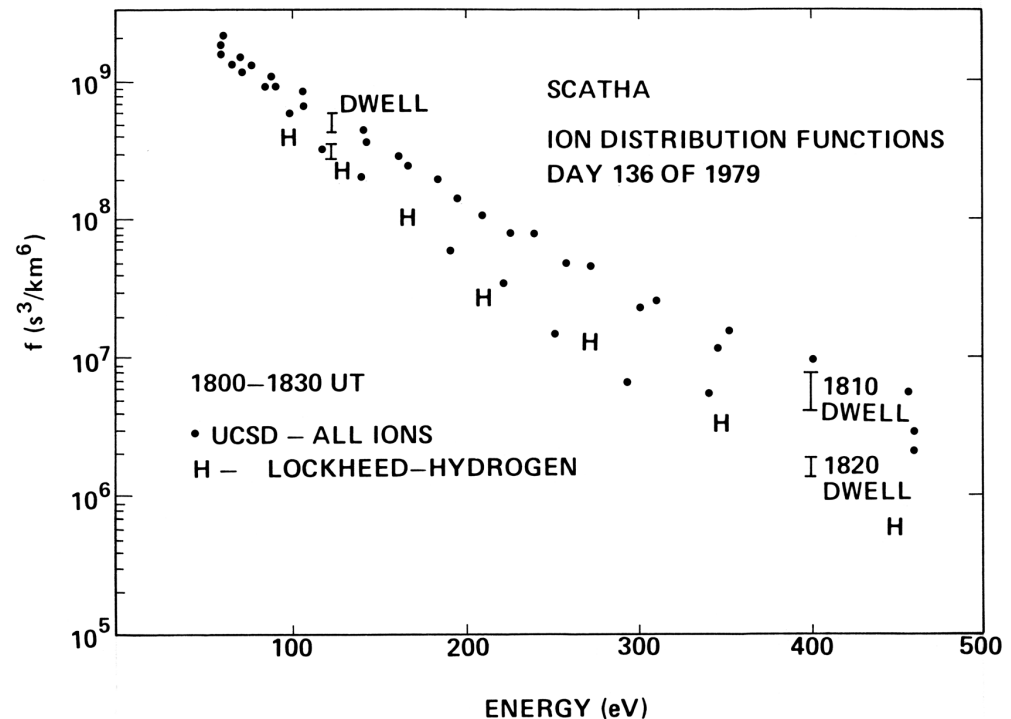
Mass Spectra - Day 136

- Data from DE-1 had shown that the equatorially trapped plasmas were primarily hydrogen
- These data showed that was true at energies above the range we observed on DE-1.
- Jack Quinn ran this for me. He and Dick Johnson did a paper on the SCATHA observations for the trapped plasmas.



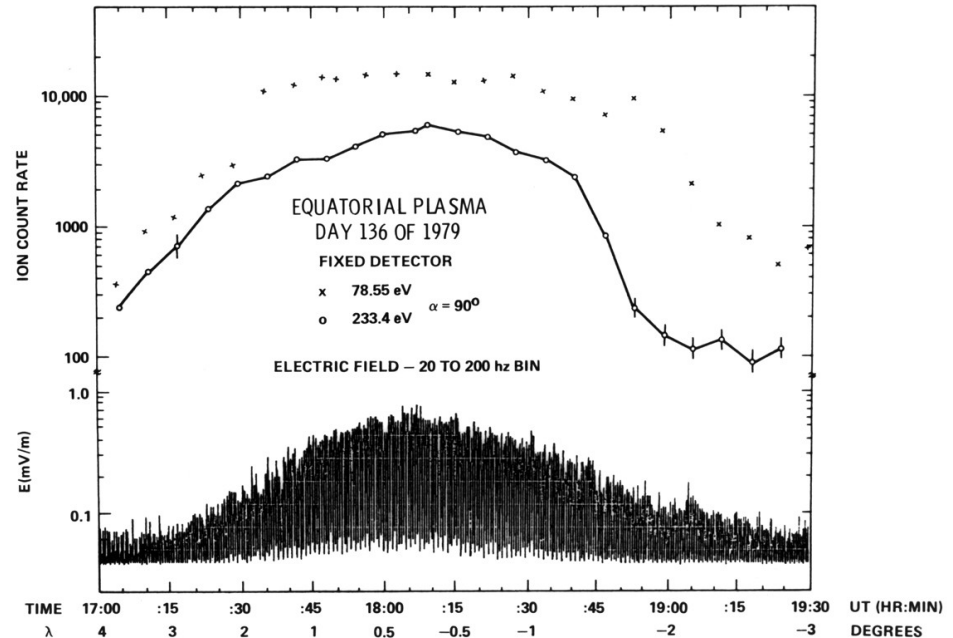
Energy Distribution Functions – Day 136

- Comparing the distribution functions observed by the Lockheed ion mass spectrometer and the UCSD instrument. This is partly a check on calibration. The vertical error bars show the range of values found during the 'dwell' observations at specific energies. Also, this is a good check on any temporal fluctuations, since the Lockheed sensor takes about 30 minutes to get decent statistics.
- It was important to know that the ions were mostly hydrogen. Dave Young, and the rest of the GEOS crew, had just spent a lot of time showing preferential helium (He+) heating due to ion cyclotron waves. Later work with DE-1 showed that H+ and He+ were more or less equally heated.



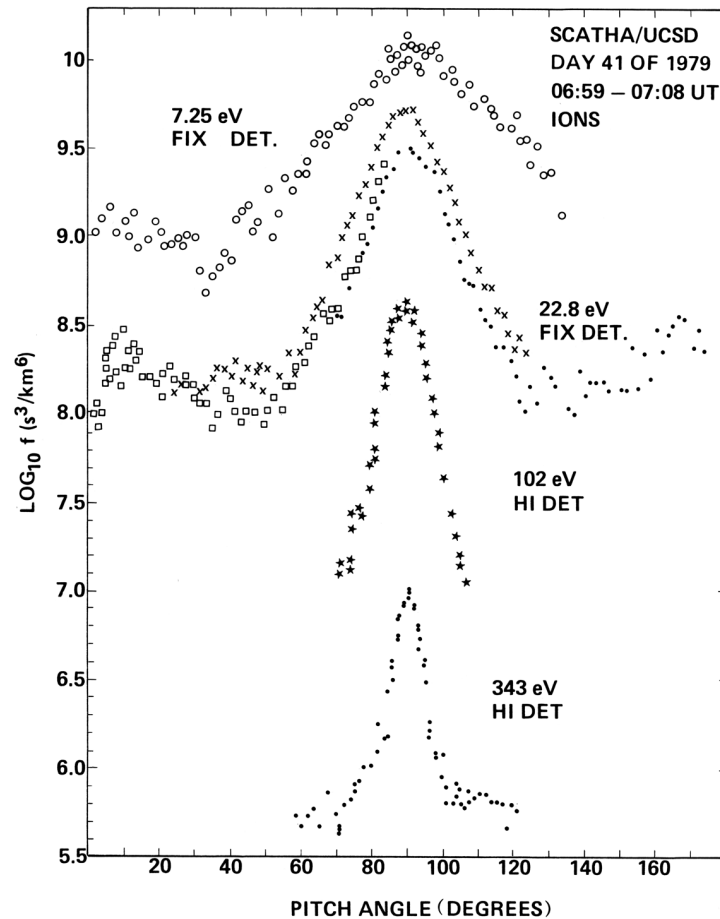
Trapped Plasma - Trapped Waves

- The equatorially trapped plasma coincides with the equatorial noise.



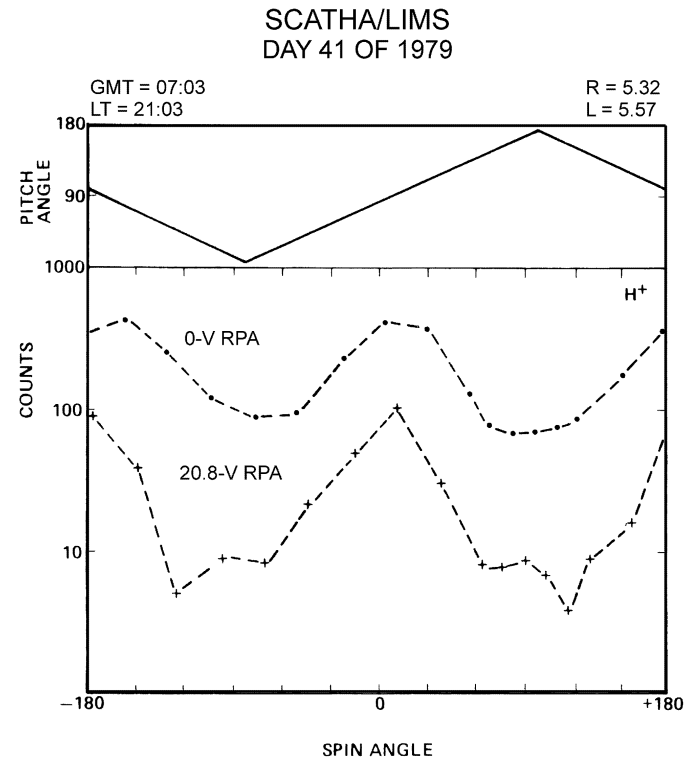
Pitch angle distributions - Day 41

- These early data correspond to the only event in the brief interval when the LIMS instrument worked - it failed after 10 days or so.



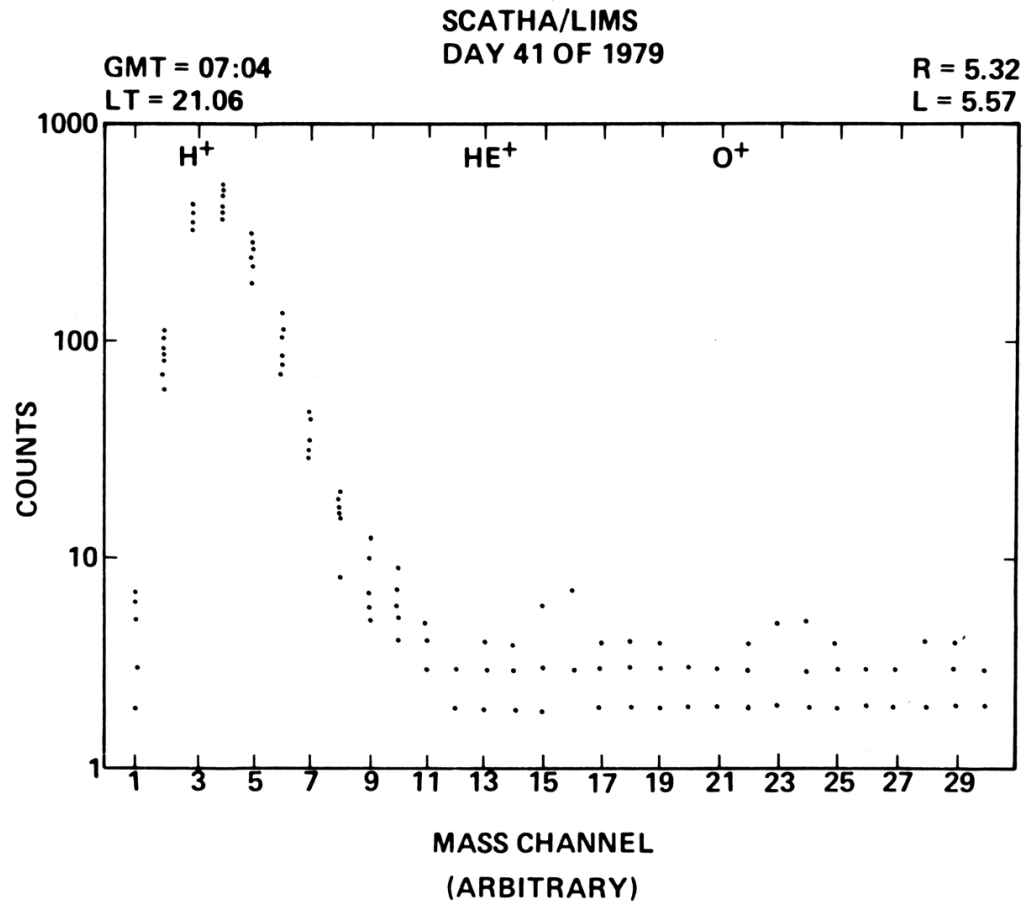
Mass Spectra - Day 41

- The LIMS instrument had an RPA design good to about 50 Volts.
- The equatorially trapped plasma was characterized by a temperature of 10-20 eV in energy analysis. The plasma density was about 10 cm^{-3} .
- Data were from Dave Reasoner and Paul Craven.



Mass Composition – Day 41

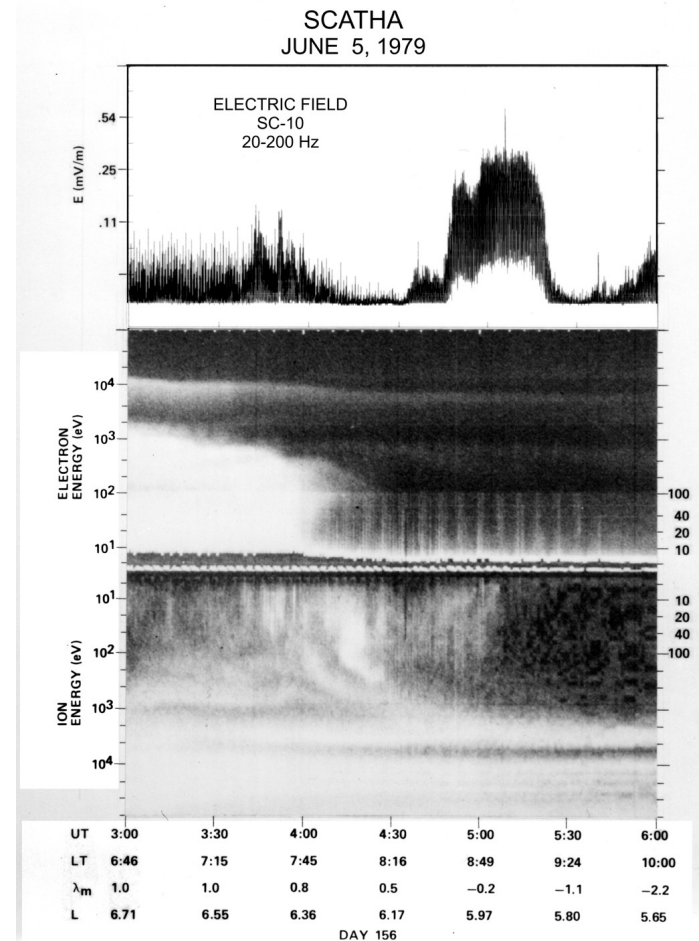
- Here is the mass analysis on the LIMS data.



- More figures from day 41 are not part of the original talk

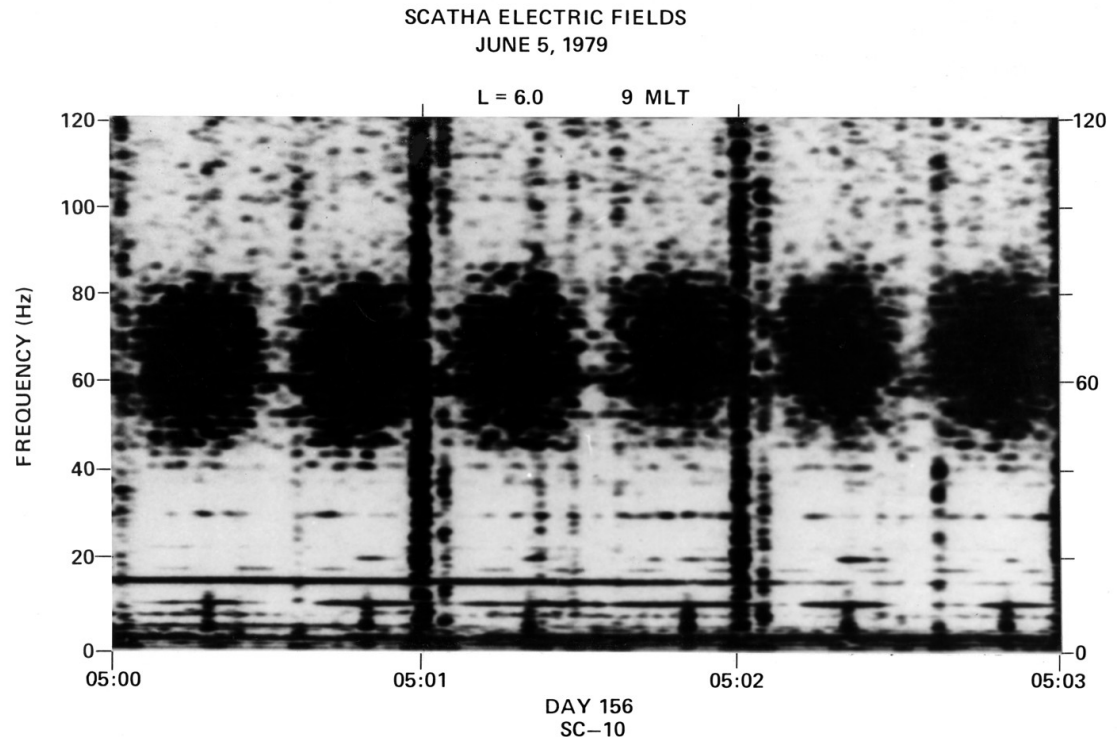
Day 156

- The next step is to look at the “wideband” data from the wave instrument. This was one of the best days, spectrally speaking
- The electric field is in the top panel, the plasmas in the bottom 2 panels. Not much plasma – kind of a weak event, in fact.



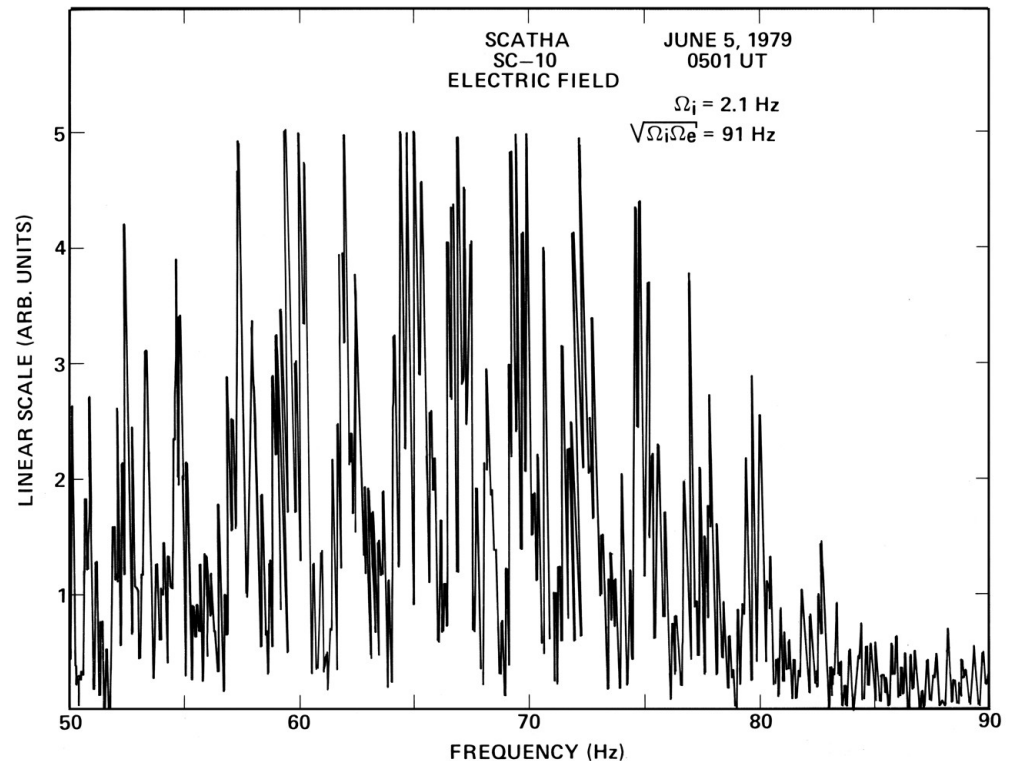
Equatorial Noise - Day 156

- Three satellite rotations (3 minutes) of data are shown. The highly polarized waves are spin modulated. The frequency range is centered a little over 60 Hz. These are ion Bernstein waves, just below the LHR.



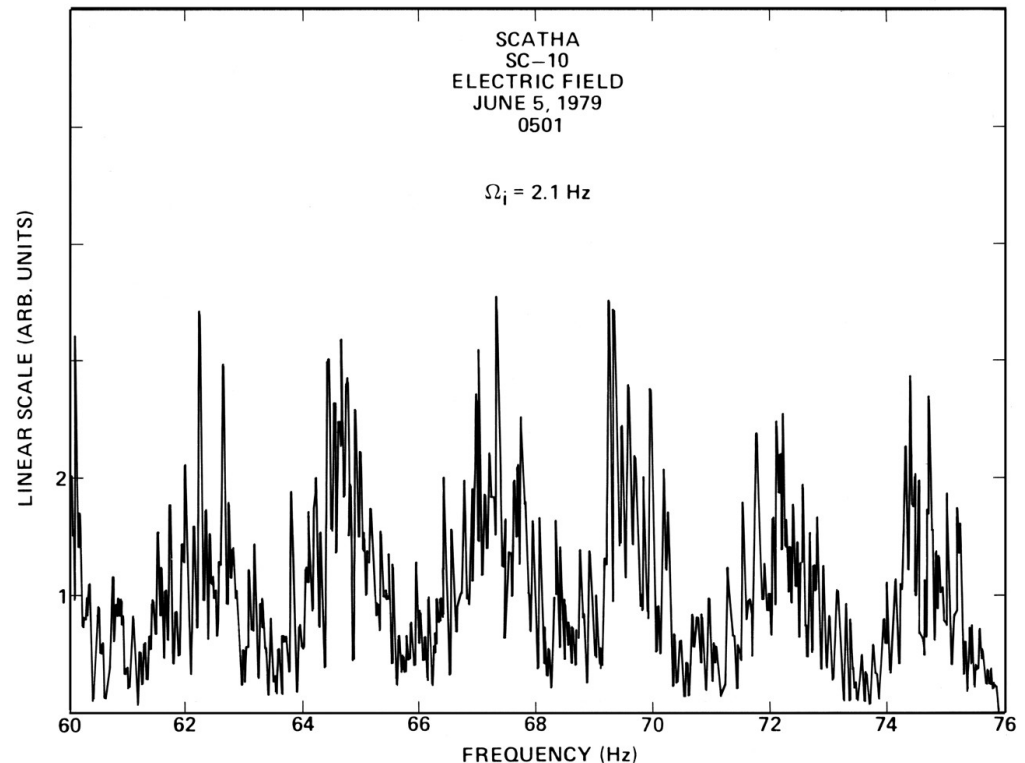
Spectral Analysis

- Here is a line plot view. Note that the geometric mean gyrofrequency (here, 91 Hz), is close to the lower-hybrid resonance frequency in these regions.
- The Bernstein modes are more or less spaced at f_{ci}



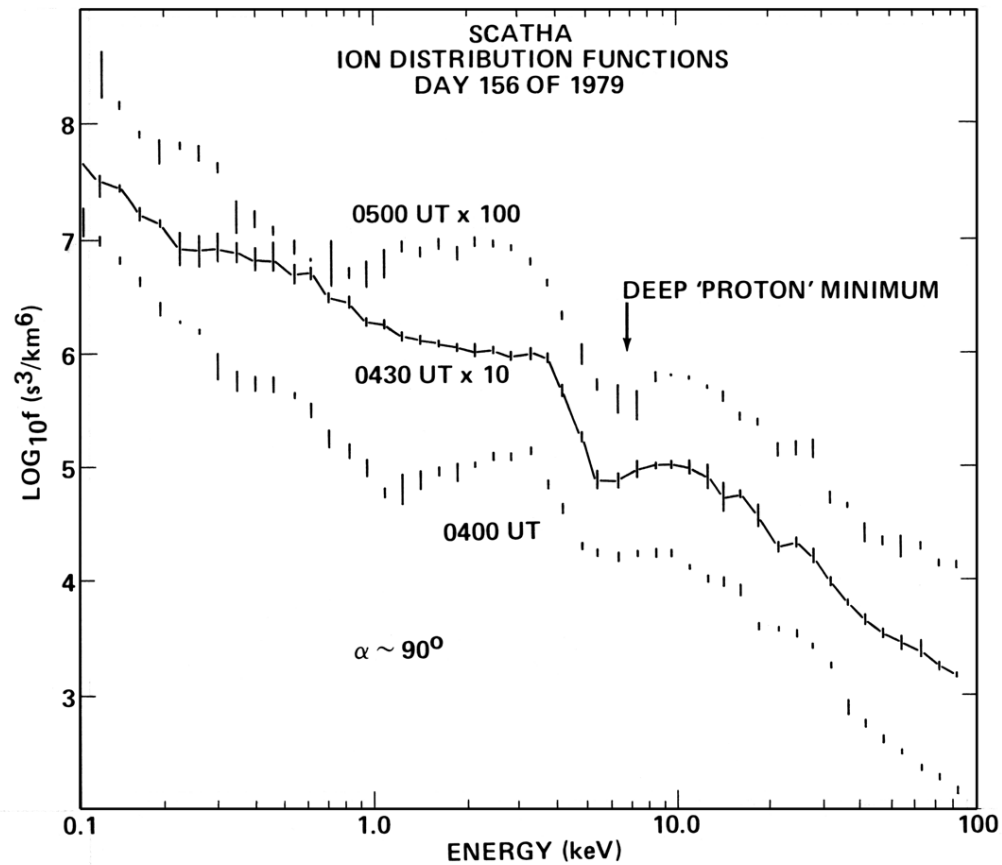
Spectral Analysis - 2

- Jim Roeder and I spent a lot of time at Aerospace Corp analyzing the wideband data. Here is the characteristic Bernstein mode structure - aka ion cyclotron harmonics ($n+1/2 f_{ci}$)
- Note here that the spacing seems to be a little larger than the local gyrofrequency.
- Additional figures, including the original graph paper versions



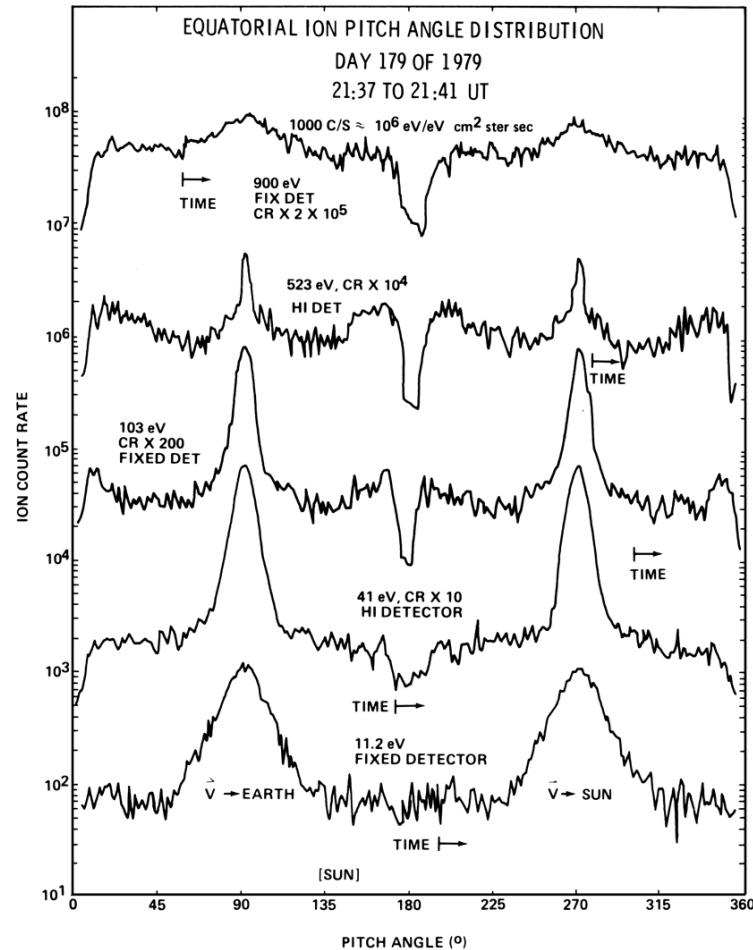
Deep Proton Minimum

- There is a free energy source
- It is there even if you calculate the reduced distribution function, which is what goes into the wave growth calculations. ($v^2 f$)



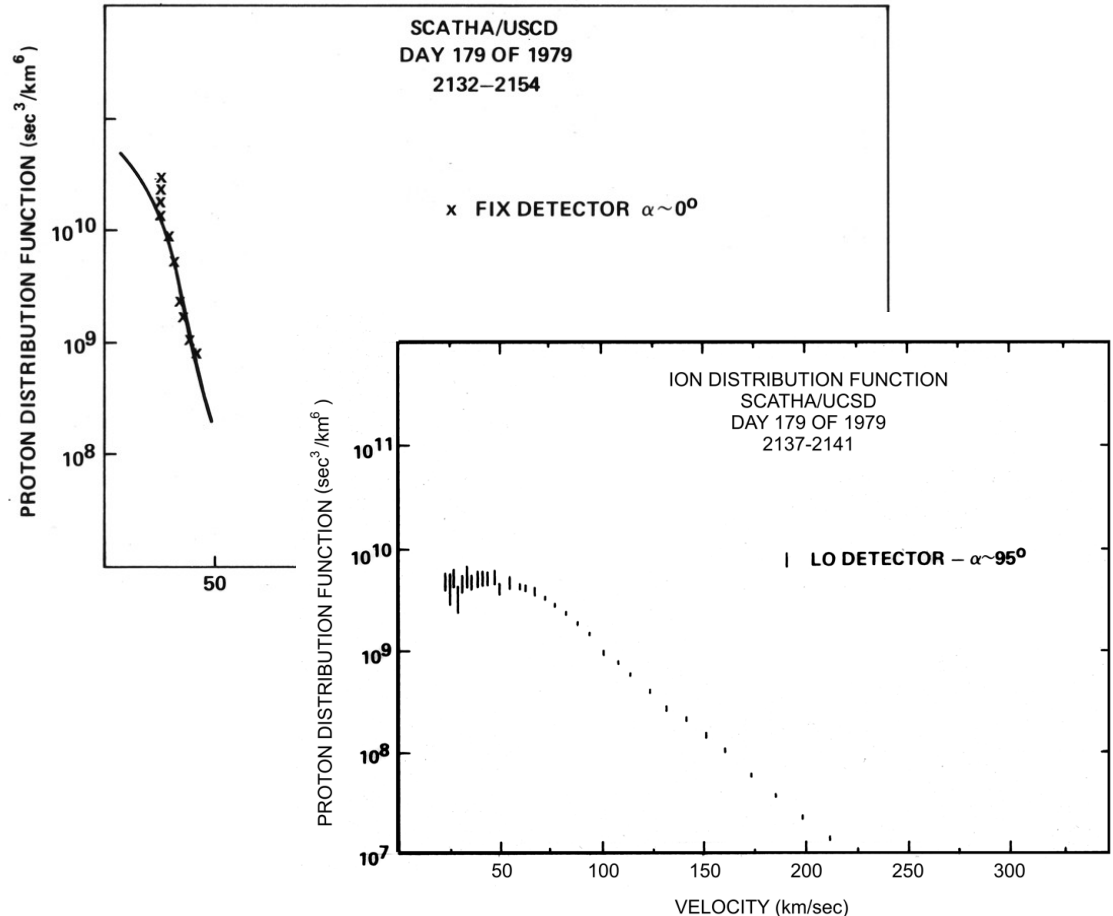
Day 179 α distribution

- This is one of the two events in my original publication.
- The distributions narrow with increasing energy.



Low Energy Ion Velocity DF

- As noted earlier, the distribution functions are not really Maxwellian. They have a peculiar shape – flat at low velocities for the perpendicular ions – field-aligned ions are lower energy.



Diffusion

- The SCATHA data pretty much match up with the calculations for quasi-linear diffusion.

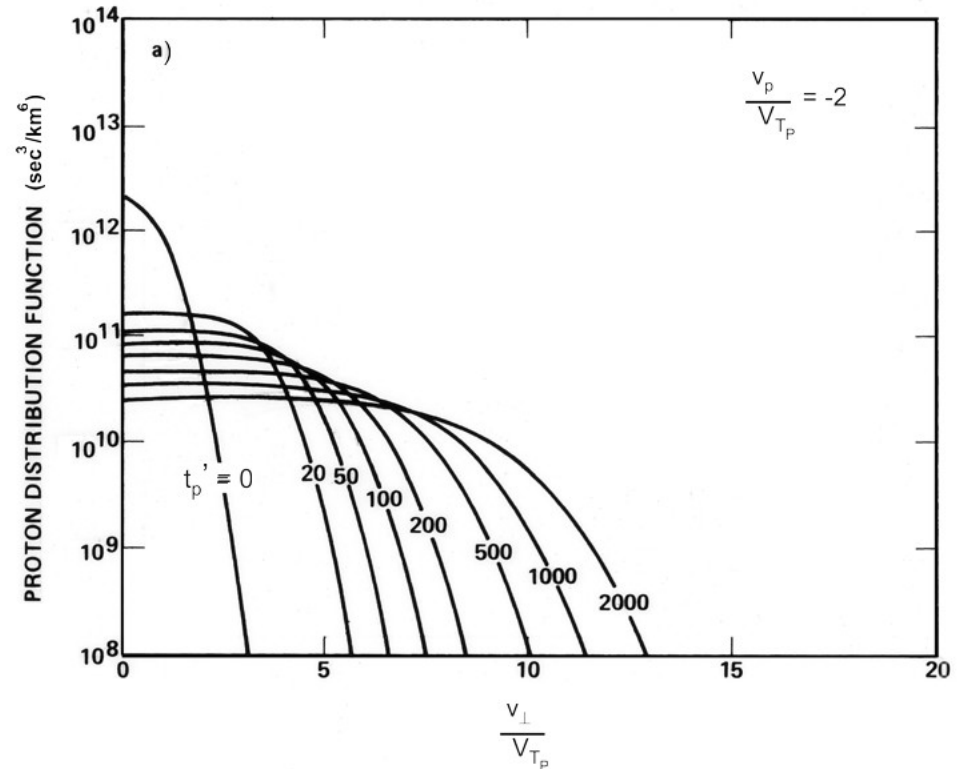
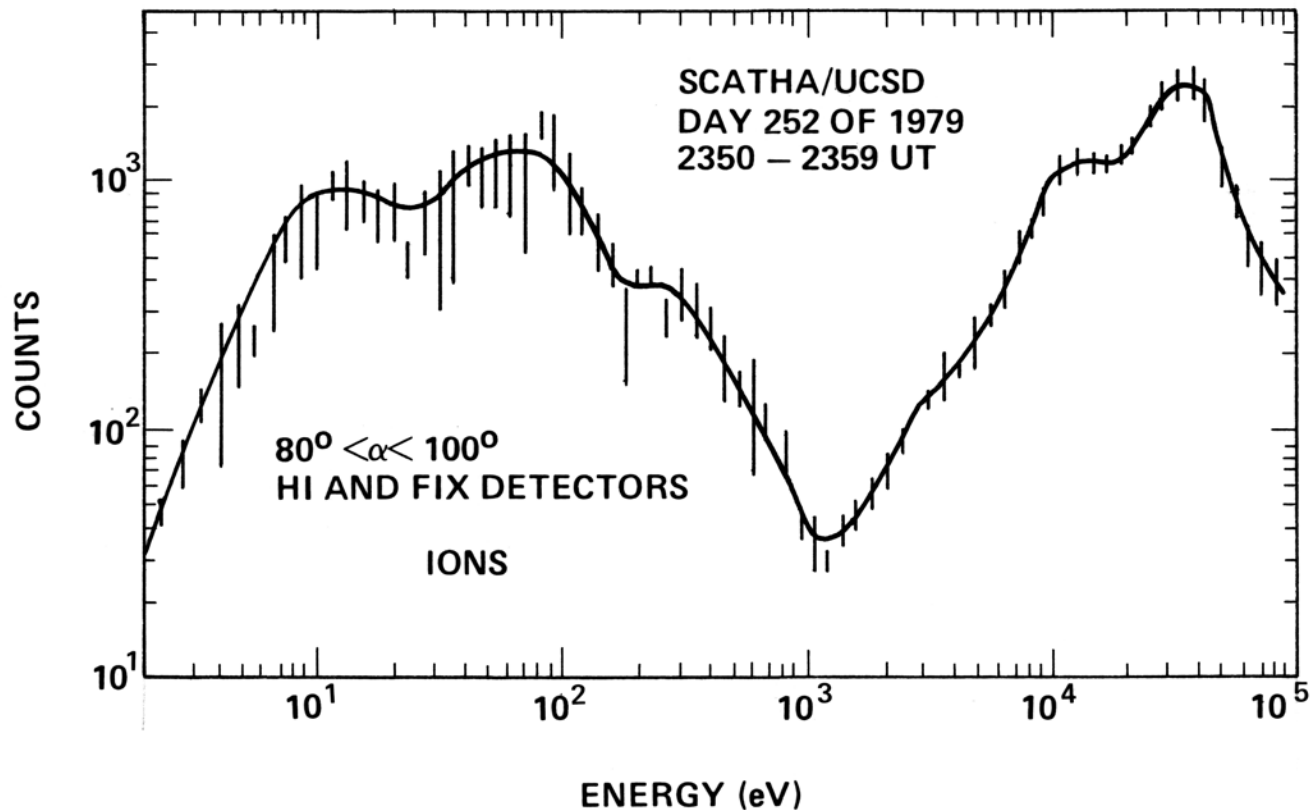


FIGURE 6 DUSENBERRY AND LYONS
JGR, P7634, 1981
QUASI LINEAR DIFFUSION

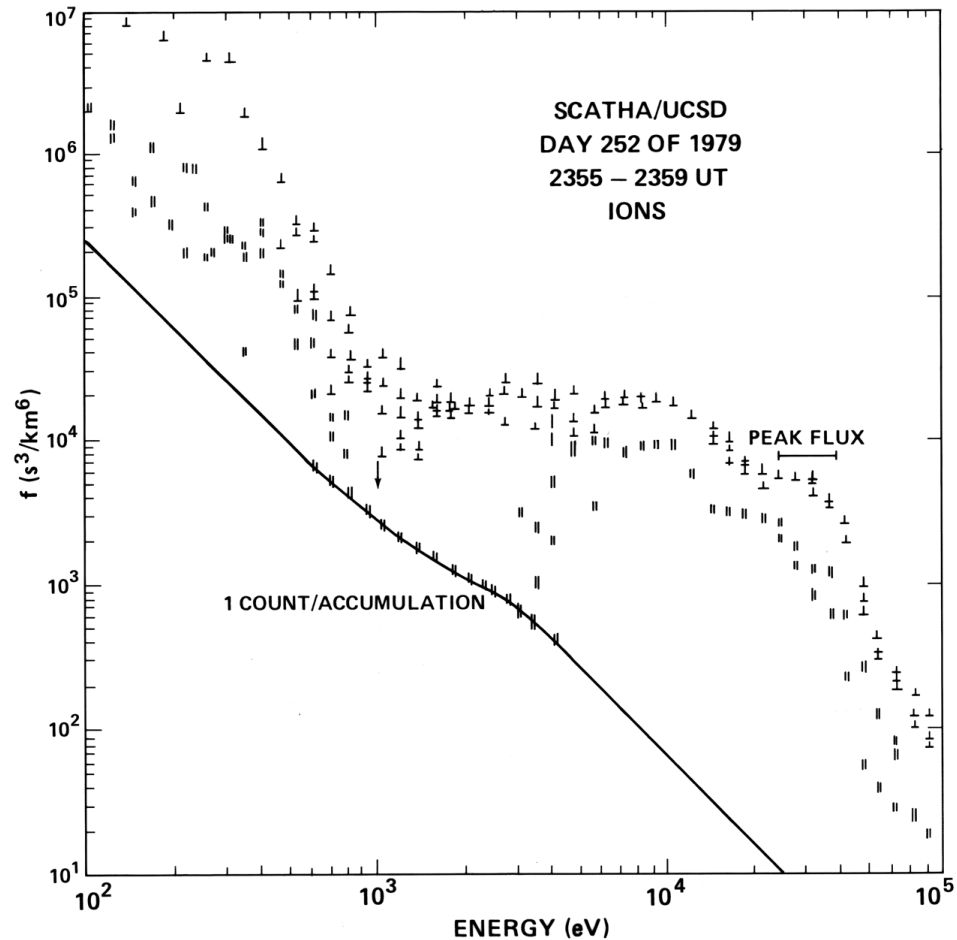
Day 252 Count Rate

- Again, there is a free energy source due to magnetospheric convection.

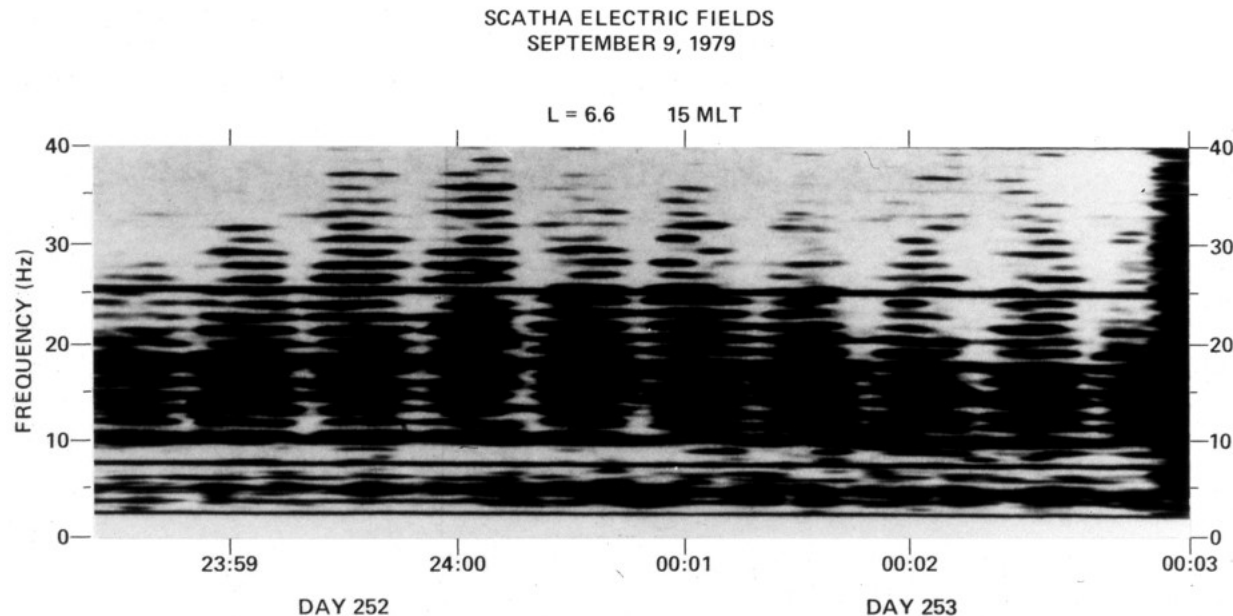


Hi-Energy Ion DF – Day 252

- It's not as obvious in phase space density, but it is still there.
- The ions are anisotropic, as well.



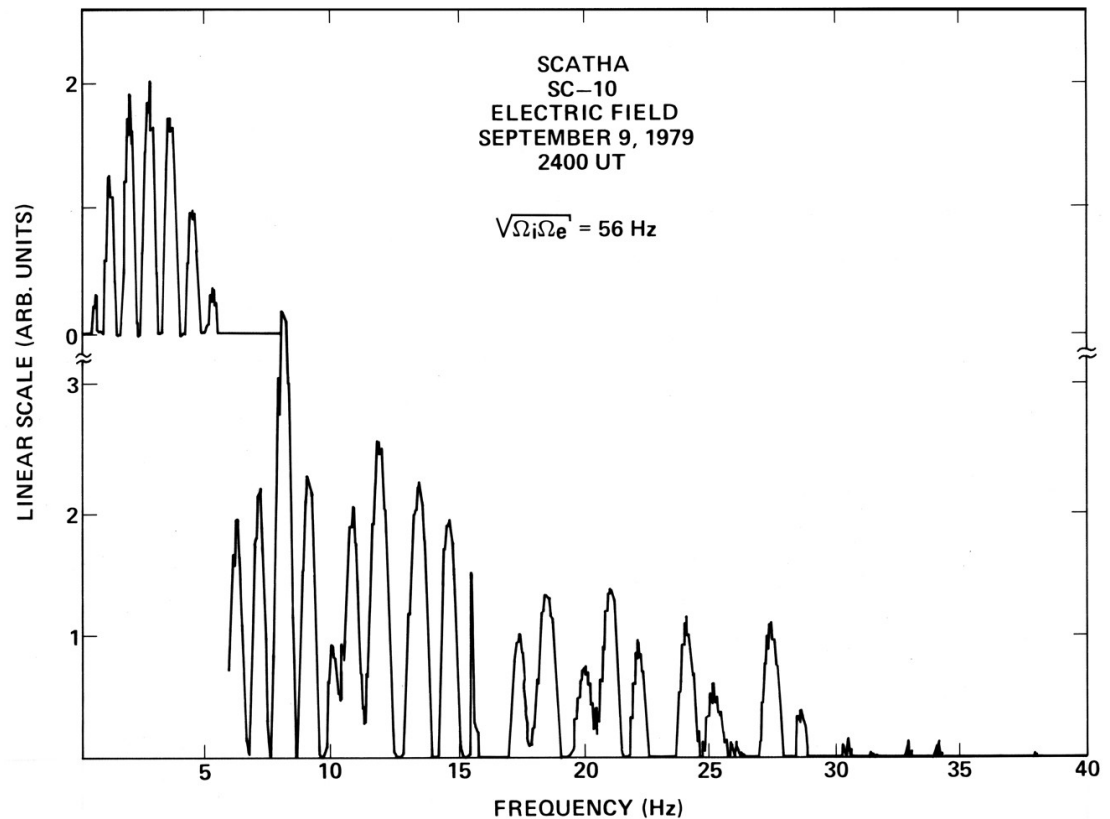
Equatorial Noise



- Again, we see the Bernstein modes. The electric field amplitude is spin-modulated due to the wave polarization.

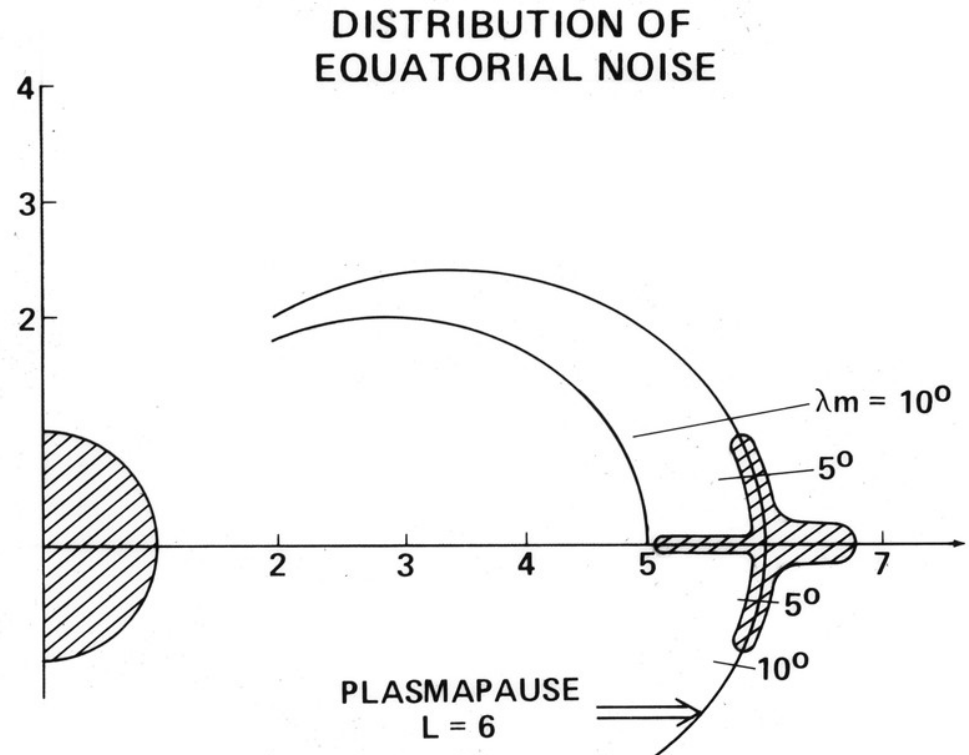
Ion cyclotron harmonics or Bernstein waves

- Below the geometric mean gyrofrequency, and spaced with the proton gyro-frequency.
- Extra look at low frequency fine structure



Distribution of Equatorial Noise

- This sketch is due to Tom Aggson. We later used it in the 1987 paper.



Conclusions

- The data sets illustrated here showed most of the components of a plasma heating process.
 - An energy source (deep proton minimum)
 - Plasma Waves (ion Bernstein waves)
 - Heated Plasma (equatorially trapped ions)
- Missing –
 - the cold ion ‘source’ plasma (later observed with DE-1)
 - A complete theory linking the 4 items